MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

ETM7096 - MICROWAVE COMMUNICATION SYSTEMS

29 MAY 2017
7:30 p.m - 10:30 p.m
(3 Hours)

INSTRUCTION TO STUDENT

1. This question paper consists of 7 pages (including the cover page) with **FIVE (5) questions** only.

2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) List THREE (3) radio frequency (RF) issues in dealing with high frequency circuits or systems.

[3 Marks]

(b) Discuss the advantages and disadvantages of microwave frequency in communication system.

[8 Marks]

(c) An RF signal with a power of 25 dBm is connected to a bandpass filter with insertion loss of 2.5 dB and then followed with an amplifier with power gain of 10 dB. What is the RF power that will be measured at the filter output (in mW) and amplifier output (in mW)?

[4 Marks]

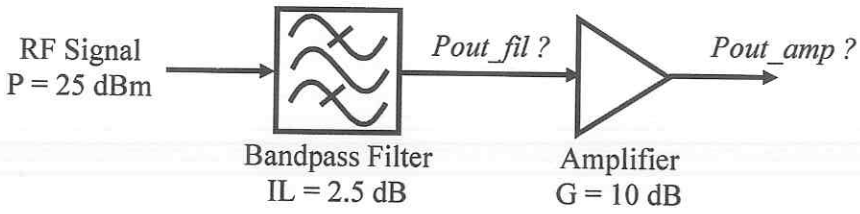

Figure Q1

(d) The distance between a ground station and a geostationary satellite in a 4 GHz downlink transmission is 35,860 km. Given that the Effective Isotropic Radiated Power (*EIRP*) of the satellite is 300 W, the gain of antenna at the ground station is 59.76 dB, the total receiver temperature (T) is 600 K and the noise bandwidth is 4.5 MHz. Compute both the Space Loss Ratio (SLR) and the Signal-to-Noise ratio (SNR) in dB. (Boltzmann's constant, $k = 1.38 \times 10^{-23}$ J/K).

[5 Marks]

Question 2

(a) State THREE (3) advantages and TWO (2) disadvantages of single-conversion heterodyne receiver over the direct-conversion (homodyne) radio receiver.

[5 Marks]

(b) An RF signal with input power (P_{in}) of 2 dBm and frequency (F_{RF}) of 900 MHz is connected to a receiver front-end shown in Figure Q2, with the given insertion loss (IL) of the filters, gain (G) of the amplifiers and conversion gain (CG) of the mixers.

(i) Name the type of receiver architecture used in this system.

[1 Mark]

Continued....

(ii) Determine the IF power that will be measured at the first mixer output (P_{out_mixer1}, in mW).

[2 Marks]

(iii) The first local oscillator is using low or high tracking ?

[1 Mark]

(iv) List the frequencies after the first mixer output

[2 Marks]

(v) Determine the down-converted IF frequency after the first IF filter, F_{IF1}.

[1 Mark]

(vi) Determine the IF power that will be measured at the second mixer output (P_{out_mixer2}, in mW).

[2 Marks]

(vii) The second local oscillator is using low or high tracking ?

[1 Mark]

(viii) List the frequencies after the second mixer output

[2 Marks]

(ix) Determine the down-converted IF frequency after the second IF filter, F_{IF2}.

[1 Mark]

(x) Determine the IF power that will be measured at IF amplifier output (P_{out_IF2}, in mW).

[2 Marks]

(Note: Ignore the loss of connectors and assume all connectors are the same)

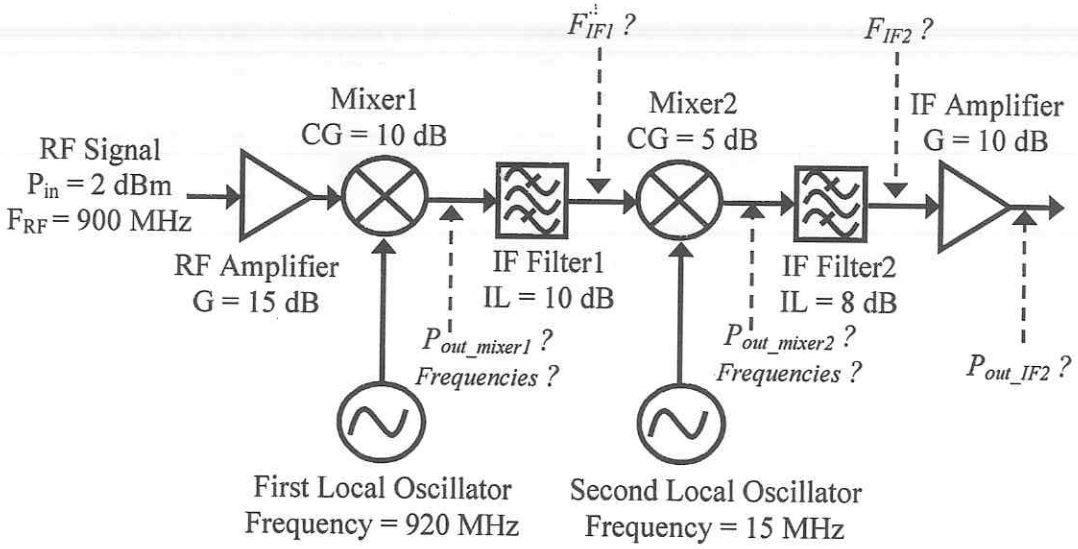

Figure Q2

Continued....

Question 3

(a) A coaxial line has the following parameters: resistance per unit length, $R' = 6$ ohm/km, inductance per unit length, $L' = 2.2$ mH/km, capacitance per unit length, $C' = 0.005$ μF/km and conductance per unit length, $G' = 0.05$ μmho/km. Note that R', L', G' and C' are typically frequency dependent. Determine the following:

(i) the characteristic impedance Z_0 and propagation constant γ at 1 kHz,
[6 marks]

(ii) the attenuation (in dB), phase shift and phase velocity of the signal when the line length is 100 km.
[6 marks]

(b) A lossless transmission line circuit is shown in Figure Q3 with characteristic impedance $Z_c = 50$ ohm, load impedance $Z_L = 25$ ohm, given that source impedance $Z_s = Z_c$ at 1.8 GHz. Determine the following:

(i) the load reflection coefficient (Γ_L) at 1.8 GHz,
[2 marks]

(ii) the input impedance Z_{in}.
[6 marks]

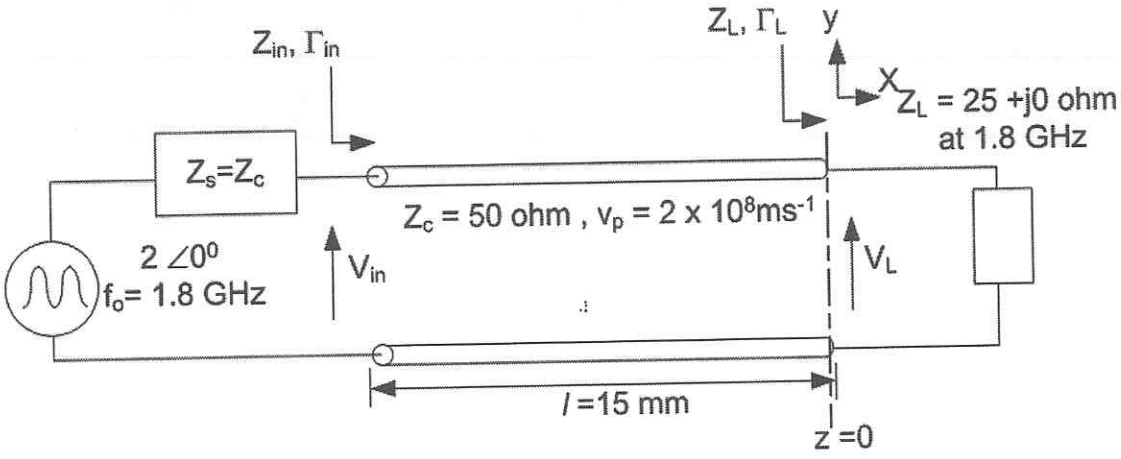

Figure Q3

Continued....

Question 4

(a) With an aid of suitable diagrams, describe the FOUR (4) propagation modes in a waveguide or transmission lines.

[6 Marks]

(b) The patch antenna shown in Figure Q4 has input impedance of 112.5 Ω at 1GHz. A quarter-wavelength transformer is designed for to transform this impedance to 50 Ω. This quarter-wavelength transformer is to be implemented with microstrip transmission line for a high frequency planar printed circuit board on a 1.2 mm thick duroid substrate (with relative dielectric constant, $\varepsilon_r = 2.3$).

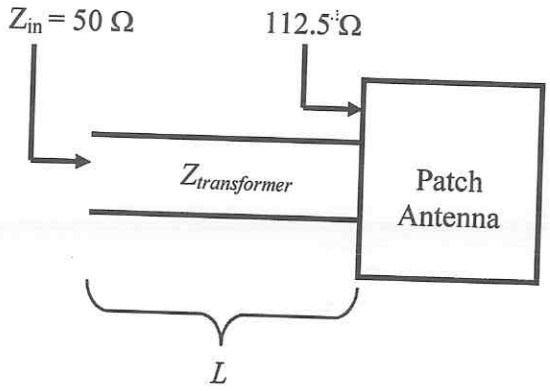

Figure Q4

(i) Determine the impedance of the quarter-wavelength transformer, $Z_{transformer}$.

[4 Marks]

(ii) Determine the width of the conducting strip for the quarter-wavelength transformer. ***(Hints** – Use the microstrip equations listed in Appendix)*

[4 Marks]

(iii) Determine the phase constant, phase velocity, guide wavelength and length (L) of the quarter-wavelength transformer at 1 GHz.

[6 Marks]

Continued....

Question 5

(a) A filter has the S_{21} (in dB) shown in Figure Q5. It is measured from approximately 400 MHz to 1200 MHz, with a 50 Ω reference impedance (Z_0).

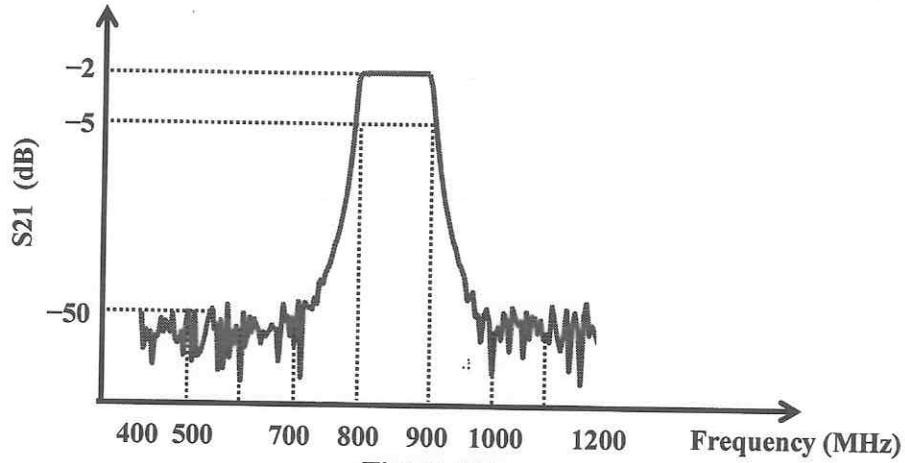

Figure Q5

(i) What type of filter is shown in the above measurement?

[1 Mark]

(ii) Determine the insertion loss, cut-off frequencies, center frequency and 3 dB bandwidth of the filter.

[5 Marks]

(iii) What are the stop-band frequencies and rejections of the filter?

[4 Marks]

(b) A device under test (DUT) has the following *S*-parameters at 1 GHz, with a 50 Ω reference impedance (Z_0) :

$$S_{11} = 0.01 \angle 0° = 0.01 + j0,$$
$$S_{21} = 0.5 \angle 10° = 0.492 + j0.087.$$

(i) Determine the input impedance (Z_{in}) of the above DUT.

[2 Marks]

(ii) Is the input of the above DUT matched to 50 Ω reference impedance? Justify your answer.

[2 Marks]

(iii) What is the input return loss of the above DUT in dB?

[2 Marks]

(iv) Is the above DUT has power gain or power loss? Justify your answer.

[2 Marks]

(v) What is the power gain or power loss of the above DUT in dB?

[2 Marks]

End of Page

Appendix

Microstrip equations for dielectric constant and characteristic impedance

- Given the dimensions of microstrip line, characteristic impedance can be calculated as:

$$Z_0 = \begin{cases} \dfrac{60}{\sqrt{\varepsilon_e}} \ln\left(\dfrac{8d}{W} + \dfrac{W}{4d}\right) & for \quad W/d \le 1 \\ \dfrac{120\pi}{\sqrt{\varepsilon_e}\left[\dfrac{W}{d} + 1.393 + 0.667 \ln\left(\dfrac{W}{d} + 1.444\right)\right]} & for \quad W/d \ge 1 \end{cases}$$

where

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \cdot \frac{1}{\sqrt{1 + 12d/W}}$$

- For a given characteristic impedance and dielectric constant, the W/d ratio can be found as:

$$\frac{W}{d} = \frac{8e^A}{e^{2A} - 2} \qquad for \quad W/d < 2$$

where

$$A = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right)$$